Psychological Impact of Closed Head Injury

Danielle Blackfield

Dr. Stephen Petrill

The Ohio State University

Abstract

Closed head injury is a type of Traumatic Brain Injury that has the potential to disrupt normal brain functioning. Studies show that many who experience head injuries, such as concussions, are at risk of heightened depression and anxiety, of suffering from sleep irregularities and personality changes, as well as deficits in cognitive functioning. The purpose of this study is to help better understand the range of symptoms that occur as a result of closed head injuries among a community sample of college students, and to explore the nature of the relations between concussions and these psychological dimensions. One study using two samples was conducted using volunteers from the Ohio State community who may have suffered a range of head injuries. Data was collected via self-report questionnaire, using up to 9 inventories that specifically pertained to head injuries, depression, anxiety, personality, sleep irregularities, or cognitive functioning. Correlations, t-tests, and ANOVA, were used in order to evaluate any potential relationships. The results of the study suggest a relationship between head injury and personality trends and sleep irregularities. This study can provide insight into the full range of the effects of closed head injury, as well as can shed light on the mechanisms in which they occur.

Psychological Impact of Closed Head Injury

Traumatic brain injury (TBI) is caused by a bump, blow, or jolt to the head or a penetrating head injury that disrupts the normal function of the brain (CDC, 2015). Concussions are a type of closed head injury and the most common type of traumatic brain injury and are caused by a force to the head that causes the head and brain to move back and forth, and can result in a change normal brain functioning (CDC, 2014). Concussions affect hundreds of thousands of Americans every year. In 2010, it was estimated that traumatic brain injuries caused 2.2 million emergency room visits, 280,000 hospitalizations, and 50,000 deaths (CDC, 2015). Further, the majority of concussions occur as a result of everyday activities, with 40.5% of concussions caused by falls (CDC, 2015). Despite the prevalence of concussions, not nearly enough is known about the short-term and longer-term psychological impacts. Some, but not all, of concussed individuals experience post-concussion syndrome (PCS), which is a medical disorder in which concussed individuals experience physical and psychological symptoms after concussion (Mayo Clinic, 2014). Many of these symptoms manifest a week after concussion; however if they persist beyond a few months, the individual is considered to have post-concussion syndrome (Daneshvar, Riley, Nowinski, Stern, & Cantu, 2011.). Concussions are extremely prevalent and costly, and can impact anyone regardless of age, occupation, and lifestyle. Little is known about the psychological effects of concussions, and return to normal physical activity too early can have dire consequences. Moreover, without a full understanding of the effects of concussions, one cannot know if someone has fully recovered from a concussion, which puts people at risk for second impact syndrome. Second impact syndrome (SIS) is the result of a person, usually an athlete, who returns to physical activity before sufficient recovery from a prior TBI, and experiences a second head injury (Bey & Ostick, 2009). This can result in brain swelling and herniation, and even death (Bey & Ostick, 2009).

It is commonly accepted that there is a positive relationship between post- concussion syndrome and depression. (Broshek, De Marco & Freeman, 2014). Research suggests that 12-44% of those who have suffered a concussion experience some degree of depression in the first few months (Broshek et al., 2014). Mayberg's cortical-limbic model of depression suggests that depressive symptoms and sadness are mediated by blood flow to the limbic, subcortical, and frontal regions of the brain (Mayberg, 2003). Studies have found reduced connectivity in these regions, which may explain the common occurrence of depression post-concussion (Broshek et al., 2014). Chen et al. (2008) used a matched pairs design comparing concussed athletes with depressions symptoms and concussed athletes without depressive symptoms. The study found reduced activity in the dorsolateral prefrontal cortex, dorsal anterior cingulate cortex, insular cortex, thalamus, and striatum in the depressive athlete sample, which is consistent with cortical-limbic model (Broshek et al., 2014). Chen et al. also found that those with concussion had less grey matter, and those with depressive symptoms had further loss (Broshek et al., 2014). They found a negative correlation of grey matter loss and depressive symptoms, such that less grey matter is associated with greater depression (Broshek et al., 2014). Chrisman et al. (2013) surveyed families with children under 18, and found a correlation of depression and concussions in youth (Chrisman & Richardson, 2013). Although the present study will not be utilizing participants under 18, the Chrisman study provides further evidence that depression occurs among those with concussions.

Didehbani et al. (2013) studied retired NFL athletes, and found that they reported depression symptoms at a higher rate than the general population with age and race matched. The study found that players who experienced three or more concussions were three times more likely to suffer from depression compared to retired NFL players without a history of concussions (Didehbani, Cullum, Mansinghani, Conover, & Hart Jr., 2013). They found $r = .43$, between number of concussions and BDI—II scores, which supports the idea that multiple concussions increase the likelihood of suffering from depression (Didehbani et al., 2013). Overall, the conclusion is that there is a positive correlation between the quantity of concussions and the presence of depression.

Anxiety is also believed to occur after concussions, but findings are mixed (Broshek et al., 2014). Few studies exist specifically examining anxiety; often an anxiety questionnaire is added to a depression study. However, there are two primary theories regarding the existence of anxiety post-concussion. The indirect theory is that anxiety and concussions follow a diathesis-stress model (Broshek et al., 2014). The diathesis-stress model states that an individual has a level of genetic predisposition to a particular condition and that a threshold level of stress will trigger that condition. Regarding concussions, the idea is that a person has a level of a genetic predisposition to anxiety and that the consequences of the concussion (i.e. cognitive dysfunction, sleep difficulties, etc.) cause stress that triggers the anxiety. The other theory is more direct, which is that the injury caused by the concussion itself causes damage to the brain that increases the likelihood of anxiety (Broshek et al., 2014).

Sleep dysfunction is commonly reported post-concussion, although the estimates of the percentage of concussed individuals suffering from sleep irregularities is varied. A matched paired study of concussed athletes and healthy athletes matched on a variety of subject variables (age, gender, education, age they started playing organized sports) found significant differences regarding sleep, the extent of reported physical difficulties (dizziness, headaches, head pressure), cognitive difficulties (concentration), and neurobehavioral difficulties (sleep, irritability, sadness) (Gosselin, Lassonde, Petit, Leclerc, Mongrain, Collie, & Montplaisir, 2007). They found that the concussed sample scored worse on the Pittsburgh Sleep Quality Index regarding subjective sleep quality, sleep disturbances, and daytime dysfunction (Gosselin et al., 2007). Overall, there are measurable differences in subjective sleep quality reporting between concussed and healthy individuals.

Sleep problems regarding the circadian rhythm, hypersomnia, parasomnias, and insomnia are commonly reported, with hypersomnia and insomnia as the most common complaints (Jaffee, Winter, Jones, & Ling, 2014). Those with a malfunctioning circadian rhythm often are suffering from delayed sleep phase syndrome (Jaffee et al., 2014). In this syndrome, their sleep cycle is ill timed, where they cannot fall asleep until late at night and as a result wake up much later in the day (Jaffee et al., 2014). This is problematic for those who must work or attend school. It is theorized that delayed melatonin release and body temperature maintenance is the cause, or that it is caused by a loss of the ability of light to regulate the circadian rhythm (Jaffee et al., 2014). Hypersomnia, a feeling of persistent tiredness, is believed to be caused by injury to the hypothalamus (Jaffee et al., 2014). The cells of the posterolateral hypothalamus produce hypocretin-1, a neurotransmitter responsible for maintaining wakefulness (Jaffee et al., 2014). In a study by Baumann, Stocker, Imhof et al. (2005), 95% of participants had low hypocretin-1 levels after a moderate brain injury (Jaffee et al., 2014). The most common parasomnia reported is REM Behavior Disorder, a loss of skeletal muscle paralysis during REM sleep, which leads individuals to enact dream behaviors (Jaffee et al., 2014). It is hypothesized that this condition is caused by damage to the mechanisms in the brainstem responsible for the inhibition of spinal motor neurons during REM sleep (Jaffee et al., 2014). Insomnia is believed to be caused by dysregulation in the ability to shift between sleep states or the ability to maintain a sleep state (Jaffee et al., 2014). It has been found that higher severity of PCS predicts risk for more persistent insomnia (Jaffee et al., 2014). The general conclusion is that those with PCS complain of a variety of sleep difficulties, but further research needs to be done to understand the cause, the extent, and the relationship of these complaints with TBI.

Much of the prior literature regarding personality and concussions focuses on the presence of psychopathology post-concussion. Research suggests that pre-injury personality traits may become more pronounced post-concussion, including narcissism, grandiosity, perfectionism, dependency, and borderline personality (Garden, Sullivan, & Lange, 2010). Mendez et al. (2011) found that traits commonly associated with PCS include irritability, aggression with little to no provocation, emotional and mood problems, apathy, and lack of spontaneity, which are traits that would be considered negative (Mendez, Owens, Jimenez, Peppers & Licht, 2011). The study examined the difference between veterans who suffered concussions caused by blunt force and those whose condition came from blast force trauma. Blast force is considered to be more severe, and blast force victims were comparably more cold-hearted, aloof, introverted, and apathetic, suggesting a relationship between severity of concussion and presence of negative traits (Mendez et al., 2011). Garden et al. (2010) used the Million Clinical Multiaxial Inventory III (MCMI-III), an assessment of psychopathology, and found concussed individuals showed significant elevations compared to the general population on the negativistic, depressive, anxiety, dependent, sadistic, somatic, and borderline scales (Mendez, et al., 2011). Ruocco, Swirsky-Sacchetti, and Choca (2007) used the MCMI-III on participants with PCS and found elevations on the histrionic, compulsive, and somatoform scales. (Mendez et al., 2011). Arbisi, Polusny, Erbes, Thuras, and Reddy (2011) evaluated mild

TBI participants using the Minnesota Multiphasic Personality Inventory, a test of personality and psychopathology, and found elevations on the scales for hypochondriasis, depression, and hysteria. The findings of these assessments suggest a higher rate of personality disorders among those with PCS. Other disorders may be more prevent among concussed individuals too, as a study of 129 concussed participants found 63% qualified for Axis I (clinical disorders such as depression, schizophrenia, etc) or Axis II disorders (personality disorders, mental retardation), which is a rate much higher than that of the general population. Although this thesis project is not examining psychopathological trends among those with PCS, the research showing trends with psychopathology suggests that there could also be trends with personality traits.

Studies of executive functioning, specifically working memory, have interesting findings. Concussed individuals often report difficulty with concentration, memory of recent events, and ability to do their job (McAllister, Saykin, Flashman, Sparling, Johnson, Guerin, Mamourian, Weaver, & Yanofsky, 1998). However, research shows that concussed participants and controls perform comparable on executive functioning tasks. McAllister et al. (1998) compared healthy controls with mild TBI participants. They used the n-back task, where a participant has to recall the location of a stimulus n steps earlier in the task. The brain activation patterns between the concussed and controls were different in response to the working memory task. The most prominent difference was that in the 1-back to 2-back comparison, the control participants only required use of the frontal region, whereas the concussed participants required continued use of a variety of working memory regions (McAllister et al., 1998). The difference in processing suggests the ability to allocate processing resources after a concussion may be impaired, which may explain complaints of ‘having to work harder’ even though they perform similar to controls (McAllister et al., 1998). There is evidence to suggest that TBI has a different impact on people of different ages. This is supported by differences within working memory post-concussion. Research shows similar results when comparing the working memory of adults with and without concussion; however, the results are quite different when examining children. Keightley et. al (2014) ran a matched pairs study on concussed youth with participants in the control and experimental groups matched by age (Keightley, Saluja, Chen, Leonard, Petrides, & Ptito, 2014). The study found that unlike adults, children post-concussion perform significantly worse on working memory tasks, and specific showed poorer accuracy on verbal and visual tasks (Keightley et al., 2014). This suggests that youth are unable to engage in the same compensatory behaviors that adults use, and that concussions affect age groups differently. This further supports the continuation of closed head injury research, as the subject variable of age needs to be further explored.

Prior research and statistics regarding concussions heavily suggest that expanding the basic research literature on closed head injuries can help save the well-being and lives of those who have suffered from traumatic brain injuries. It is commonly accepted that closed head injuries are problematic, but more research is required to understand the full extent of damage caused by closed head injuries. Prior research regarding head injuries typically focuses on concussions and has only focused on a single dimension or has only worked with a specific population (retired professional athletes of a certain sport, high school athletes, etc.). This project takes a more holistic approach to help increase closed head injury knowledge that is applicable to anyone who has suffered a closed head injury, regardless of whether it was a sports-related closed head injury. It is commonly understood that physical activity and exercise are necessities for achieving a well-rounded and healthy lifestyle. Sports-related concussions make up a large percentage of the TBI statistics, and improper care due to lack of understanding often leads to athletes sustaining multiple concussions. However, almost any form of physical activity, ranging from organized sports well-known for concussions such as football and soccer, to simple activities such as driving and using stairs, puts people at risk for a potentially life-altering traumatic brain injury of which we have limited knowledge. Without examining the psychological impact of closed head injury, people run the risk of returning to physical activity too early and developing second impact syndrome. Non-fatal consequences can be harmful as well, with some side effects being maladaptive.

This project examined five different psychological aspects: depression, anxiety, executive functioning, sleep irregularities, and personality trends. Prior literature has indicated that four of the factors are affected closed head injury, but research has yet to address personality trends. The project was consisted of two samples and the results were compared. Most of the prior literature surrounding head injuries is focused specifically on concussions. While this project looks to study general closed head injuries among a college community sample, there is still relevance and insight to be gained from prior research on concussions among clinical samples. The study used a self-report measure using subjects from the Ohio State community who have suffered closed head injuries. Much of the prior research examined concussions within a clinical population, whereas this study examined a community sample to investigate how closed head injuries in general may impact college students and their psychological functioning. The hypothesis based on the prior literature is that there will be a positive correlation between the severity of concussion and the depression symptoms, anxiety symptoms, sleep irregularities and working memory complaints. Since there is limited research on personality traits post-concussion, there is no formal hypothesis regarding personality trends, although it is possible that individuals with head injuries may share certain personality traits.

Methods

Participants: Data collection occurred online via a self-report survey using volunteers of the Research Experience Program (REP), who are Ohio State students. The study was collected in two samples across successive semesters. Sample 1 consisted of 47 participants, 19 who identified as male and 27 who identified as female. 22 participants indicated that they had experienced a head injury, and 7 indicated they had experienced more than one head injury. 43 participants had played a sport at some point, and 20 participants indicated that their head injury occurred during a sporting event (see Table 1). The participant pool predominantly identified as White/European American as shown in Table 2.

Sample 2 of 130 participants had 37 male participants, 91 female participants, and two individuals who identified as other. 43 participants indicated that they had experienced a head injury, and 18 had experienced more than one head injury. 115 participants had played a sport, and 33 participants experienced a head injury during a sporting event (see Table 3). Similar to Sample 1, the participants of Sample 2 were mostly White/European American as shown in Table 4, and three participants identified as biracial (see Table 4b).

Measures and Procedure: Using Qualtrics, a self-report survey was collected using a variety of measures that have been established as valid and reliable, and have been used in prior concussion research. Participants were simply asked to respond yes or no to questions asking: if they had experience a head injury, if they had experienced more than one head injury, if they had participated in a sport, and if the head injury was sustained while participating in a sport. Depression was assessed using the Beck Depression Inventory (BDI), and anxiety was assessed using the Beck Anxiety Inventory (BAI), Mathematic Anxiety Ratings Test (MARS) and the

Spence. Personality was assessed using a shortened version of the Big 5 Inventory and Rothbart, measures that evaluate personality traits, and are not used to identify those with psychopathology. Sleep Irregularities were evaluated using the Iowa Sleep Disturbance Inventory (ISDI) and executive functioning was assessed using the Barkley and Murphy Questionnaire. The self-report survey provided the necessary data to identify and evaluate the severity and quantity of concussions and the extent of self-reported impairment in the five dimensions.

Sample 2 was evaluated using the same inventories as Sample 1 but depression, anxiety, and ADHD measures were omitted due to results found among the Sample 1 as well as the length of the survey impaired the ability to recruit participants (see below). The goal with Sample 2 was to replicate the significant results found with Sample 1.

The analysis of the data was conducted using SPSS version 24.0. Descriptive statistics were analyzed first, then inferential statistics, such as t-tests using gender, sustained head injury, and sustained more than one head injury. Analysis of variance was only performed if more than one independent variable was significant after performing a t-test.

Results

The purpose of this study was to examine the relationship of head injuries with Depression, Anxiety, Executive Functioning, Sleep Irregularities, and Personality trends using students from the REP subject pool using an online questionnaire. It was predicted that the sample will show elevated rates of Depression, Anxiety, and Sleep Irregularities, as well as problems with Executive Functioning.

Descriptively, the results from Sample show that the sample consisted of almost half females and half males, and almost 50% of the participants had sustained head injuries. Sample 2 was less balanced from a gender perspective with approximately 70% of the sample as female. However, from a racial/ethnic background stand point, there was somewhat more diversity within Sample 2. Further, the distributions of both samples for various variables were normal, and showed that the sample was behaving as expected. The skewness and kurtosis for all variables except hyperactivity were within the normal range (see Table 5). Hyperactivity, with a skewness of 1.064 was outside of the normal -1 to 1 range, and demonstrates that the participants of Sample 1 were exceptionally low in hyperactivity. Skewness and kurtosis for all variables of Sample 2 were within normal ranges (see Table 6). The preliminary results have shown that it is possible to conduct head injury research with meaningful results while using the REP subject pool.

Turning to inferential statistics, both t-tests and a dichotomous point biserial correlations were run using data from Sample 1. The t-test investigated the independent variable of Presence/Absence of Head Injury. The dependent variables were Depression, Anxiety, Conscientiousness, Extraversion, Openness, Agreeableness, Neuroticism, Excessive Sleep, Movement During Sleep, Insomnia, Irregular Sleep, Hyperactivity, and Inattention. T -tests indicated significant differences between Head injury and Non-head Injury groups for four variables within Sample 1 (Table 7): Conscientiousness $t(44) = 2.30$, $p =.025$, Neuroticism $t(44) = -2.60$, $p = .012$, Excessive Sleep $t(39) = -2.02$, $p =.05$, and Insomnia $t(42) = 2.30$, $p = .03$. As expected, the correlation between presence of Head Injury and outcomes measures were also significant for the same four variables: Conscientiousness $r(44) = -.33$, $p = .025$, Neuroticism $r(44) = .37$, $p = .012$, Excessive Sleep $r(39) = .31$, $p = .05$, and Insomnia $r(42) = -.33$, $p = .03$.

A second series of T-tests were conducted examining “More than one head injury” as the independent variable. These analyses indicated significant results with three variables: Insomnia

$t(42) = 2.6$, $p = .01$, Neuroticism $t(44) = -2.09$, $p = .04$, and Extraversion $t(44) = 2.19$, $p = .03$ (see Table 9). A t-test comparing Sex and the outcome variables found two significant relationships: Depression $t(43) = -2.08$, $p = .04$ and Neuroticism $t(44) = -3.99$, $p = .00$. All other comparisons were nonsignificant.

Given the significant T-test results, a 2 x 2 ANOVA was conducted examining the effects of Sex, Head injury, and Sex x Head Injury on the dependent variable Neuroticism. There was a significant main effect for sex $F(1,45) = 16.70$, $p = .00$. There was not a significant main effect for head injury, however it was close to significant $F(1,45) = 2.98$, $p = .09$.

The second ANOVA test compared Sex and More Than One Head Injury with the dependent variable Neuroticism. Again, there was a significant main effect for sex $F(1) = 8.20$, $p = .01$. There was no significant main effect for head injury, however it was also close to significant $F(1) = 3.18$, $p = .08$.

Based on the findings from Sample 1 results, and due to the fact that the length of the questionnaire was hurting response rates, several changes were made to the survey for Sample 2. The first change was shortening the survey, as the average time for completion of the survey was 40-50 minutes, and the goal was closer to 30. In order to shorten the survey, several questionnaires were removed. Since prior research has already established the relationship between concussions and both anxiety and depression, the BDI, BAI, MARS, and Spence were removed, as the Sample 1 results did not suggest that these relationships were significant or of reasonable effective size. The Sample 1 results found significant relationships with two out of the five traits of the Big 5, so emphasis was placed on the Big 5 as the measurement of personality. Therefore, the Rothbart was removed, and the full Big 5 Inventory was used, instead of the amended version. These changes were relatively simple, and the overall design of the study did not change drastically. In summary, the inventory was simplified and more focused on areas that have shown to be of interest.

Although the changes to the study between Sample 1 and 2 were minor, the results with Sample 1 were unable to be replicated with Sample 2. No significant results were found with Sample 2 between Head Injury and the outcome variables, even after expanding to the full Big 5 inventory to examine the significant results found with the amended Big 5 inventory with Sample 1. There was a significant relationship between Sex and two outcome variables: neuroticism $t(118) = 2.80$, $p = .01$ and agreeableness $t(120) = -2.76$, $p = .01$.

Discussion

The purpose of this study was to examine if there is a relationship between head injury and depression, anxiety, sleep irregularities, executive function, and personality. Prior research has indicated that there is a relationship between head injuries and increased depression, anxiety, sleep irregularities, as well as has a relationship with changes in executive function. Minimal research had been conducted regarding head injury and personality trends after sustaining a head injury. However, the results of this study suggested that there may be a relationship between head injury and personality traits. The results of Sample 1 indicated a significant relationship with the personality traits of conscientiousness and neuroticism. This study was also able to replicate the findings of other research that discovered a relationship between head injury and sleep irregularities, as Sample 1 discovered a significant relationship with irregularities such as insomnia and excessive sleep. The correlation of these relationships were moderate, as they were all around 0.3. For personality traits, the findings suggest that those with head injuries are likely to be more conscientious and less neurotic. The relationship of head injuries and conscientiousness is opposite of what would be expected, but could possibly be attributed to a coincidence with the personality of the sample. For sleep, individuals with head injuries scored higher on the subscale for insomnia and lower on the subscale for excessive sleep. This makes logical sense in that if a head injury is related to someone having difficulty sleeping, they probably are not also sleeping too much.

Although some findings may be of interest for follow up studies, there are many limitations to consider. For one, the REP subject pool, while useful, is limited in its diversity. The study lacked diversity in terms of how diversity was evaluated in the study—race and age. The vast majority of participants in both samples identified as White/European American, which demonstrates the lack of racial diversity. The REP subject pool predominantly of participants in the typical age range of roughly 18-22, and does not allow for insight on the impact of head injuries on individuals outside of that age range. This study is looking at self-reports of ‘closed head injuries’, which is both subjective and vague, and may be interpreted differently by participants. Further, head injuries were evaluated by a categorical variable of “yes or no”, and no data of continuous evaluation of head injury severity or how recent the injury occurred was collected. Throughout the study, there was attrition, as most scales did not have enough responses to match the number of participants enrolled in the study. In addition, this study is only post-morbid, and is unable to determine any causal relationships.

While there are many limits and the results were not replicated, the research is still useful and of practical importance and can help other researchers, as well as the general population. The results the first sample indicate that personality traits and sleep irregularities may be an important area of future research. Neuroticism and insomnia had several significant relationships, and may be specific aspects for further research. Many of the participants in this study had experienced a head injury, which testifies to the prevalence of head injuries in the community, and validates the importance of research on head injuries. Of the participants in the study, many reported having sustained their head injury while participating in a sport. Research surrounding head injuries can help progress the social movement and get the public to take closed head injury seriously. This potential for change is especially important regarding sport-related head injuries, which society is currently dismissive of. Future studies could include examination of personality and sleep trends among clinical populations or could examine community populations using more specific criteria for head injuries. Increasing the sample size and increasing sample diversity are also important improvements for future research.

Although limited, this project helped make a contribution in expanding the knowledge on this medical and psychological condition, which can help direct further research create more effective patient-specific treatments. Medical professionals still do not fully understand what damage and symptoms can occur post-concussion and further research is still needed to help unveil all of the potential risks associated with closed head injury. If more research is conducted on closed head injury, doctors will have a better idea of what symptoms and issues may arise post-concussion, and when they are likely to occur. By learning more and increasing the seriousness of regard for closed head injury, precautionary measures will become more common and allow persons to return to physical activity when it is safe, and thus reduce risk of head injury-related harm.

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Tables

Table 1
Demographic Information Sample 1

Sex	N	%
Male	19	41.3
Female	27	58.7
Sustained head injury		
Yes	22	47.8
No	24	52.8
More than one head injury		
Yes	7	15.2
No	39	84.8
Played a sport		
Yes	43	91.5
No	4	8.5
Sustained head injury while playing a sport		
Yes	20	42.6
No	27	57.4

Table 2
Racial Demographic Sample 1

Race	N	%
African-American	3	6.4
Asian	5	10.4
Hispanic	0	0
White	40	83.3
Other	0	0

Table 3
Demographic Information Sample 2

Sex	N	%
Male	37	28.5
Female	91	70.0
Other	2	1.5
Sustained head injury		
Yes	43	33.6
No	85	66.4
More than one head injury		
Yes	18	14.1
No	110	85.9
Played a sport		
Yes	115	89.8
No	13	10.2
Sustained head injury while playing a sport		
Yes	33	25.8
No	95	74.2

Table 4
Racial Demographic Sample 2

Race	N	%
African-American	7	5.4
Asian	20	15.4
Hispanic	2	1.5
White	99	76.1
Other	2	1.5

Table 4b
Biracial Demographic Sample 2

	Race				
	African-American	Asian/Asian-American	Hispanic	White/European American	Other
N	0	1	0	1	0
	0	1	0	1	0
	0	0	0	1	1

Table 5
Variable Outcomes for Sample 1

Variable	N	Min.	Max.	Mean	Std. Deviation	Skewness Statistic	Kurtosis Statistic
Anxiety	47	20.00	48.00	27.36	6.27	.93	1.006
Depression	46	20.00	51.00	28.87	7.81	.92	.51
Executive Function							
Hyperactivity	42	9.00	29.00	15.31	4.49	1.06	1.14
Inattention	43	9.00	28.00	15.74	4.86	.83	.15
Personality							
Extraversion	47	3.00	10.00	6.72	1.96	-.26	-.58
Agreeableness	47	4.00	10.00	7.89	1.42	-.47	-.034
Conscientiousness	47	3.00	9.00	6.89	1.66	-.60	-.31
Neuroticism	47	2.00	10.00	6.04	1.96	.047	-.68
Openness	47	3.00	10.00	6.43	1.57	.091	-.40
Sleep Irregularity							
Excessive Sleeping	42	7.00	12.00	9.29	1.09	.11	.10
Movement	45	6.00	12.00	9.29	2.26	-.18	-1.45
Irregular Behaviors	44	5.00	10.00	7.86	1.77	-.15	-1.26
Insomnia	45	11.00	22.00	16.33	3.88	-.13	-1.63

Table 6

Variable Outcomes for Sample 2

Variable	N	Min.	Max.	Mean	Std. Deviation	Skewness Statistic	Kurtosis Statistic
Personality							
Extraversion	120	3.00	36.00	21.00	7.58	-.005	-.67
Agreeableness	122	17.00	38.00	29.47	4.49	-.43	-.43
Conscientiousness	123	9.00	38.00	25.68	5.66	.11	-.25
Neuroticism	120	.00	39.00	18.68	7.68	.063	.18
Openness	122	19.00	42.00	30.40	4.51	-.11	.009
Sleep Irregularity							
Excessive Sleeping	124	7.00	12.00	9.60	1.12	-.30	-.224
Movement	124	6.00	12.00	8.98	2.37	.079	-1.56
Irregular Behaviors	123	5.00	10.00	7.78	1.90	-.15	-1.40
Insomnia	124	11.00	22.00	16.19	4.13	.039	-1.57

Table 7
Sample 1 T-Test Head Injury

	Head injury (sd)	No head injury (sd)	t	df	p
Depression	27.45 (8.97)	30.57 (6.32)	-1.35	43	.18
Anxiety	26.86 (7.27)	28.13 (5.22)	-.68	44	.50
Executive Function					
Hyperactivity	15.47 (5.14)	15.32 (4.03)	.11	39	.91
Inattention	16.30 (5.52)	15.36 (4.35)	.61	40	.56
Sleep Irregularity					
Insomnia	17.59 (3.76)	15.05 (3.72)	2.25	42	.03*
Irregular Sleep	7.57 (1.66)	8.05 (1.86)	-.88	41	.39
Movement	8.95 (2.46)	9.64 (2.11)	-.99	42	.33
Excessive Sleep	8.95 (.83)	9.62 (1.24)	-2.02	39	.05*
Personality					
Openness	6.82 (1.40)	6.04 (1.68)	1.69	44	.10
Neuroticism	5.27 (1.70)	6.71 (1.99)	.-2.62	44	.01*
Conscientiousness	7.41 (1.33)	6.33 (1.76)	2.32	44	.03*
Agreeableness	7.28 (1.58)	8.04 (1.30)	-.74	44	.46
Extraversion	7.13 (1.88)	6.4 (2.02)	1.25	44	.22

* denotes significance at p <0.05.

Table 8
Sample 1 T-Test Sex

	Male (sd)	Female (sd)	t	df	p
Depression	25.83 (7.59)	30.60 (7.47)	-2.08	43	.04*
Anxiety	25.21 (5.68)	28.70 (6.42)	-1.90	44	.06
Executive Function					
Hyperactivity	13.94 (4.41)	16.33 (4.46)	-1.70	39	.10
Inattention	15.00 (4.46)	16.32 (5.22)	-.85	40	.40
Sleep Irregularity					
Insomnia	17.12 (3.90)	15.81 (3.92)	1.08	42	.29
Irregular Sleep	7.53 (1.62)	8.15 (1.85)	-1.14	41	.26
Movement	9.59 (2.32)	9.07 (2.29)	.72	42	.47
Excessive Sleep	9.12 (0.99)	9.38 (1.17)	-.74	39	.47
Personality					
Openness	6.63 (1.67)	6.37 (1.47)	.560	44	.58
Neuroticism	4.84 (1.68)	6.89 (1.74)	-3.99	44	.00*
Conscientiousness	7.21 (1.65)	6.81 (1.52)	.84	44	.41
Agreeableness	8.16 (1.61)	7.74 (1.29)	.98	44	.34
Extraversion	6.37 (2.01)	7.07 (1.88)	-1.22	44	.23

Table 9

Sample 1 T-Test More than One Head Injury

	More than one (sd)	Not more than one/none (sd)	t	df	p
Depression	26.57 (9.45)	29.39 (7.61)	-.87	43	.39
Anxiety	26.43 (10.13)	27.56 (5.59)	-.43	44	.67
Executive Function					
Hyperactivity	13.83 (4.22)	15.66 (4.57)	-.91	39	.37
Inattention	15.29 (6.65)	15.97 (4.54)	-.34	40	.74
Sleep Irregularity					
Insomnia	19.71 (1.50)	15.84 (3.84)	2.61	42	.01*
Irregular Sleep	7.29 (1.89)	7.97 (1.78)	-.93	41	.36
Movement	10.43 (2.70)	9.15 (2.11)	1.39	42	.17
Excessive Sleep	9.00 (1.00)	9.35 (1.12)	-.77	39	.45
Personality					
Openness	7.00 (0.82)	6.31 (1.67)	1.06	44	.29
Neuroticism	4.71 (1.38)	6.33 (1.95)	-2.09	44	.04*
Conscientiousness	7.14 (1.77)	6.82 (1.67)	.47	44	.64
Agreeableness	7.14 (2.19)	8.05 (1.23)	-1.58	44	.12.
Extraversion	8.14 (2.54)	6.43 (1.77)	2.19	44	.03*

* denotes significance at $p < 0.05$.

Table 10

Sample 2 T-Test Head Injury

	Head injury (sd)	No head injury (sd)	t	df	p
Sleep Irregularity					
Insomnia	16.07 (4.13)	16.25 (4.16)	-.23	122	.82
Irregular Sleep	7.55 (1.89)	7.89 (1.90)	-.94	121	.35
Movement	8.61 (2.22)	9.17 (2.43)	-1.24	122	.22
Excessive Sleep	1.60 (.21)	1.60 (1.74)	-.14	122	.89
Personality					
Openness	30.37 (4.49)	30.42 (4.55)	-.062	120	.95
Neuroticism	18.40 (7.08)	18.83 (8.00)	-.29	118	.78
Conscientiousness	25.90 (6.22)	25.57 (5.40)	.30	121	.76
Agreeableness	29.71 (4.57)	29.35 (4.48)	.42	120	.68
Extraversion	22.05 (7.24)	20.48 (7.74)	1.07	118	.29

Table 11
Sample 2 T-Test Sex

	Male (sd)	Female (sd)	t	df	p
Sleep Irregularity					
Insomnia	16.40 (4.28)	16.11 (4.09)	.35	122	.73
Irregular Sleep	7.97 (1.91)	7.71 (1.90)	.69	121	.49
Movement	8.57 (2.29)	9.15 (2.39)	-1.22	122	.23
Excessive Sleep	1.64 (0.16)	1.59 (0.19)	1.40	122	.16
Personality					
Openness	30.91 (3.81)	30.20 (4.77)	.79	120	.43
Neuroticism	21.66 (7.83)	17.46 (7.32)	2.80	118	.01*
Conscientiousness	24.69 (4.64)	20.08 (5.99)	-1.24	121	.22
Agreeableness	27.74 (4.90)	30.16 (4.15)	-2.76	120	.01*
Extraversion	21.59 (7.37)	20.77 (7.70)	.53	118	.60

* denotes significance at $p < 0.05$.

Table 12
Sample 1 Correlation

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
1. Depression	1.00	-	-	-	-	-	-	-	-	-	-	-	-
2. Anxiety	.60**	1.00	-	-	-	-	-	-	-	-	-	-	-
3. Extraversion	-1.16	-.17	1.00	-	-	-	-	-	-	-	-	-	-
4. Agreeableness	-.24	-.30*	.11	1.00	-	-	-	-	-	-	-	-	-
5. Conscientiousness	-.43**	-.47**	.37*	.33*	1.00	-	-	-	-	-	-	-	-
6. Neuroticism	.52**	.48**	-.25	-.09	-.24	1.00	-	-	-	-	-	-	-
7. Openness	.02	.03	-.05	.11	.37*	.13	1.00	-	-	-	-	-	-
8. Excessive Sleep	.19	-.13	.02	.23	-.04	.32*	.26	1.00	-	-	-	-	-
9. Movement	-.29	-.29	.01	.30*	.32	-.15	.12	.11	1.00	-	-	-	-
10. Irregular Sleep	-.06	.11	.03	.22	.17	.26	.24	.19	.14	1.00	-	-	-
11. Insomnia	-.33*	-.26	.08	-.01	.15	-.32*	.02	-.24	.24	-.013	1.00	-	-
12. Inattention	.52**	.41**	-.12	-.43**	-.41**	.14	-.13	-.27	.-50**	-.35*	-.09	1.00	-
13. Hyperactive	.35*	.31*	.08	-.20	-.20	-.20	-.08	-.16	-.31*	-.19	-.08	.78**	1.00

** correlation significant at .01 level (2-tailed).
* correlation significant at .05 level (2-tailed).

Table 13
Sample 2 Correlation

	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. Irregular Sleep	1.00	-	-	-	-	-	-	-	-
2. Movement	.04	1.00	-	-	-	-	-	-	-
3. Excessive Sleep	.24**	.05	1.00	-	-	-	-	-	-
4. Insomnia	.42**	.06	.18	1.00	-	-	-	-	-
5. Openness	.01	.13	-.06	-.05	1.00	-	-	-	-
6. Neuroticism	.24**	.01	.24**	.25**	.13	1.00	-	-	-
7. Conscientiousness	.42	.15	.16	.23*	.12	.21	1.00	-	-
8. Agreeableness	-.06	.12	-.16	-.11	.27**	-.06	.13	1.00	-
9. Extraversion	-.16	-.15	-.11	.04	.11	.23*	-.01	.25**	1.00

** correlation significant at .01 level (2-tailed).
* correlation significant at .05 level (2-tailed).

Table 14a
Between-Subject Factors of ANOVA of Sex and Head Injury

	Value Label	N
Sex	Male	18
	Female	26
Head injury?	Yes	21
	No	23

Table 14b
Test of Between-Subject Effects of ANOVA of Sex and Head injury- Neuroticism as dependent variable

	Type III Sum of Squares	df	Mean Square	F	p
Corrected Model	66.47	3	22.16	8.50	0.00
Intercept	1363.61	1	1363.61	522.819	0.00
Sex	43.56	1	43.56	16.70	0.00*
Head Injury	7.77	1	7.77	2.98	0.09
Sex * Head injury	1.80	1	1.80	0.69	0.41
Error	104.33	40	2.61		
Total	1791.00	44			
Corrected Total	170.80	43			

Table 15a

Between-Subject Factors of ANOVA of Sex and More than one head injury

	Value Label	N
Sex	Male	18
	Female	26
Sustained more than one head injury?	Yes	7
	No	37

Table 15b

Test of Between-Subject Effects of ANOVA of Sex and More than one head injury- Neuroticism as dependent variable

	Type III Sum of Squares	df	Mean Square	F	p
Corrected Model	63.90	3	21.30	7.97	0.00
Intercept	678.70	1	678.70	253.96	0.00
Sex	21.92	1	21.92	8.20	0.01*
More than one head injury	8.50	1	8.50	3.18	0.08
Sex * More than one head injury	0.48	1	0.48	0.18	0.67
Error	106.90	40	2.67		
Total	1791.00	44			
Corrected Total	170.80	43			